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PRELIMINARY STUDY OF OLADE'S REGIONAL PROGRAMME ON SMALL HYDRO ELECTRIC PLANTS FOR LATIN AMERICA*

(SCOPE, CLASSIFICATION AND STRATEGY OF DEVELOPMENT)

by

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I. ANTECEDENTS AND OBJECTIVES

The energy budget of the developing model prevailin in the region is the abundance and accessibility of the economic acquisition of the oil. Nevertheless, since the crisis of 1973 and with the perspective of the exhaustion of the reserves, it was considered that the model "intensive oil" presented serious limitations in order to answer the consequent demand of a continuos growth. On the other hand, the adoption of technologies of generation and energy utilization -developed in other context with the purpose of solving different problems- meant, in the last decades, that the big social groups of the Region will continue marginated from the commercial energy circuit, emphasizing even more the differences between the social sectors.

An estimative calculation indicates that the oil and gas reserves of the region will be insufficient to cover the growing demand in a short term, even in the case that the total of these fossil combustibles would be consumed locally. On the other hand, the importation of the deficit from other regions of the planet is highly improvable due to the situation of the global reserves and to the problems of economic order.

These considerations indicate that, if the objective looked for is the harmonic development of the region, a model of energy utilization must be established to obtain the participation of all the available resources of the region that, so far, have not been or have been exploited in small amounts. It will be necessary to adopt a technological pluralism in the energy matter

to be able to answer, in an adequate manner, each specific problem.

It has been demonstrated that in the lower levels of energy consumption, relatively small increases of it are transformed into improvements more than lineally proportional in the quality of human life, being such measured in any of the usual consumers. This fact becomes particularly more relevant in the rural sector where the resistance to the technological pluralism, to solve the energy necessities, has contributed to situations of extreme precariousness and missery.

The development and implementation of Small Hydroelectrical Plants could contribute, in a meaningful manner, to the solution of these problems. Although it is true that the problems of the rural Latin American sector and of the marginated groups are not only of energy characteristics, the solution of such is necessarily linked to the global structure, of which energy constitutes an important part.

Even though individual iniciatives have been developed in Latin America, tending to the evaluation and development of Small Hydroelectrical Plants, we could say that in the hydroenergetic potential that exists in small scale as well as in the installed capacity, although efforts to establish small plants, especially for the rural utilization, have been increased, on the other hand, we are lacking a common focus -at a long term- and a general vision regarding the technological, institutional, economic, social, industrial, etc. considerations, of a massive constructive implementation.

This dis-coordination persists not only among the countries of the region, but also among institutions of the countries.

Being conscient of this panorama, as well as being aware of the importance that for the countries of the Region, acquires this renewable energy source, OLADE initiates an activity in the matter of Small Hydroelectrical Plants by formulating the program, according ot its fundamental objectives of promotion, coordination and guidance to be given to the Member States, regarding the new sources of energy.

The purpose of this document is to give the countries a frame of reference on how they can initiate their programs of Small Hydroelectrical Plants. We wish this document to be enriched by all the participants at the Seminary that will be held in Kathmandu, Nepal over this subject and in this way we will be able to send it to all the Member Countries of the organization, with the purpose of using it as a basic document in the discussions to be carried on during the first seminary that OLADE will hold in the middle of 1980 over the Small Hydroelectrical Plants, where we wish to approve the methodology that will permit any country to initiate the development of their programs on Small Hydroelectrical Plants.

II. PRESENT PANORAMA, ADVANTAGES AND LIMITATIONS IN REGARDS TO LATIN AMERICA

1. Global Socio-Economic Situation

Latin Amarica is formed by a group of developing countries with common aims and socio-economic problems.

A big percentaje of the population is gathered in the big cities while at the rural sector the population is dispersed or forming small centers of development.

The search for better living conditions and sources of work have provoked the migration from the open country to the cities, creating accute socio-economic problems and of service in such cities.

The growing rate of the population at a rural level, in the region, is generally stationary and in some cases tends to decrease due to the internal migration.

Due to the remarkable grade of dispersion of the rural population, it is not possible in economic terms to incorporate all the communities to the national electrification systems. In many cases the low consumption levels do not merit the extension of the electrical lines further than what is economically justified.

The rural economical pattern in general is basically of survival, with small business, agro-industry, artcrafts and interchange of consumption goods between the countryside and the cities.

2. The Energy Sector in General

The total energy reserves of Latin America constitute approximately 5% of the world's reserves. If we consider the total energy production including the vegetal fuels, such reaches 6%, while the total consumption of energy only represents 4.5% of the world's total.

In relation to the international commerce of energy, Latin America participates in 11.5% of the exportations and 8.8% of the importations.

The consumption levels of primary energy of commercial origin per inhabitant are, in general, reduced as they only represent 22% of the medium European values. The consumption in the rural areas and marginated sectors is even less.

For all Latin America, hydrocarbons contribute with 77.3% of the production and 64.7% of the consumption which is confronting the 21.3% that such sources contribute to the total of energy reserves.

The hydroelectrical resources have been under-utilized contributing with only 15% of the total consumption and 10% of the total production.

Other conventional sources of energy as mineral coal, nuclear energy and geothermal energy

have had a small utilization.

In regards to the origin of the energy supply it is important to underline that Latin America is basically an importing region of energy.

The importing position of the majority of the countries is a consequence almost exclusive of the oil and its derivatives and in a smaller measure of coal, as the other sources are totally local.

3. The Electrical Sector

The electrical sector in Latin America is undeveloped if we compare it with the same sector of the European countries. The levels of medium consumption per inhabitant are low in general, as they do not overpass 20% of the levels reached in Europe.

The diffusion of the electrical service is reduced since in all Latin America it only reaches 50% of the population. In the rural areas of Latin America the rendering of electrical service is reduced; it is estimated, on an average, that no more than 15% of the population is supplied.

In the rural sector particularly, the electrical service is deficient, discontinuos and in many cases it is rendered partially during the hours of bigger consumption.

From the sectorial point of view, more than 50% of the consumption is directed to the industrial and mineral activities, the domestic sector represents

between 17 and 27% and the terciary sector between 18 and 26%.

4. The Hydraulic Resource

Latin America, due to its favourable weather and geographic conditions, has a big potential of hydraulic resources with a high un-exploited and un-measured percentaje.

In general, the hydraulic resources have been used to satisfy the basic necessities of the population, the irrigation, navigation and generation of electricity.

The utilization of the hydroelectricity in the region is under the development stage and is directed, in the majority of the countries, to the fulfillment of big projects to satisfy the energy necessities of the big cities and the systems of national electric interconnections.

The quantification and utilization of the available hydraulic resources to develop the small hydroelectrical plants, as an answer to the energy necessities in the rural and isolated communities, have not been taken in consideration in the development policies of the majority of the Latin American countries.

The lack of hydrologic and climatologic information makes it difficult to obtain a rational

evaluation of the resources and it is imperative to re-enforce the entities in charge of the gathering and processing of the data and of the development of techniques and non-conventional methodologies of evaluation that could be applied to small basins.

5. Alternative Energy Sources

The development of the small hydroelectrical plants must play a very important role in the decreasing of the costs of energy and in the substitution of the fossil fuels, that in the majority of the countries are imported, decreasing therefore the dependency.

The reserves of fossil fuels (oil, natural gas, coal) are decreasing day by day and their prices are high, unstable and unpredictable.

The high costs of fuel, added to transportation costs make it economically very difficult to transport the energy to rural and isolated communities. Besides this, there are the difficulties of rendering good maintenance and repairs service to the conventional plants.

Even though the development of a hydroelectrical plant requires relatively high costs of initial investment, if we compare such with the thermal plants of the same capacity, it has been demonstrated that in the long run the hydro plants are economically more profitable with a bigger useful life and without being subjected to the raise in the fuels prices during their operation.

The enviromental effects of a small hydroelectrical plant are minimum compared to plants based on fuels. Not considering small conflicts in the use of water and soil, the effects in the quality, quantity and availability of the water are nule.

In regards to other non-conventional sources of energy, the small hydroelectrical plants count on developed technologies and reacheable to all countries. In other sources of energy as solar, biogas, aeolian, etc, the technologies are in the developing stage at the most industrialized countries. From the economic point of view, the other non-conventional sources of energy, taking in consideration the development level of the present technology, do not compete with the small hydroelectrical plants under the same conditions.

6. Rural Socio-economic Development

The lack of infrastructure to satisfy the basic necessities of the rural population is one of the factors that have propitiated the migration to the cities and the abandoning of the open country, especially by the young countrymen, bringing as a consequence the desequilibrium between the production and the consumption and accute socio-economic problems in the urban areas of the majority of the countries of the area.

The development of small hydroelectrical plants, especially in the rural non-electrified areas, would rebound in the improvement of the quality of life of the inhabitants, would permit the appearance of small

industries, and will incentivate the establishment of schools, health centers, communications, small commercial centers, etc. The irrigation through systems that will be operated hydraulic or electrically will improve the production and will motivate the countryman to work harder his lands.

7. Cultural Impact

Our rural populations are characterized by rooted cultural frames with a remarkable tendency to resist the changes and the social transformations.

The rural electrification will bring as a consequence changes in the habits of life of the countryman and will open the horizons for the cultural penetration, putting at disposition of the rural community the conveniences of the urban life.

8. Development of the Electrical Market

With the incorporation of more communities to the benefits of the electrical energy through the establishment of small hydroelectrical plants, the offer and demand of energy will be increased bringing as a consequence a better utilization and distribution of the resources.

9. Technology and Industrial Production of Equipments

The development of small hydroelectrical plants must go parallel to the development of the basic

technology for its establishment and the industrialization of the required equipment for its operation.

The advances that have been made in regards to the technology and production of equipments for the small hydroelectrical plants are incipient in Latin America and in many countries this problem has not been considered.

Some countries that have started programs for the exploitation of their hydroenergetic resources in a small scale, are not worried or do not count on resources to develop their own technologies. Nevertheless, there are important efforts of technological development in certain countries.

With the excemption of some countries that have companies dedicated to produce equipments for small hydroelectrical plants, in the major part of Latin America this industry has not been developed due, principally, to the lack of market, appropriate technologies and to the competition of producers from outside the region with a long experience in this field.

10. Utilization of the Local Resources in the Construction

In the construction of small hydroelectrical plants, as well as in the manufacturing of their equipments, it should be used up to the maximum possible the technology, materials and local manpower. Materials such as stone, gravel, sand, wood, are easy to find in the rural areas. Cement and light steel bars could be transported to the sites without difficulties. The utilization of heavy steel should be avoided as much

as possible.

For small plants the possibility of using light materials, non-conventional, as the PVC, polyethylene asbestos-cement or re-enforced cement for pressure tubings, should be studied.

The participation of the community through community boards in the fulfillment of the works will be of great importance.

11. Elaboration of Studies

The planning and establishment of a small hydroelectrical plant requires the elaboration of some previous studies: recognizing, feasibility, design, for which it is necessary to count on technical equipment, Topographers, civil, mechanic and electric Engineers, as well as the necessary instruments to make studies of: land-measuring, drilling, river gaging, laboratory of soils and materials.

In the majority of countries there is availability of personnel and equipment for the performance of these studies, nevertheless, an intensive program of development of small hydroelectrical plants must go accompanied of an accelerated plan for training of local personnel.

12. Investments and Costs

The construction of a small hydroelectrical plant in general requires a high initial investment

that in the majority of the cases is not available to the governments or organizations in charge of developing such programs.

As the objective of installing a small hydroelectrical plant obeys to purposes of social interest, in the majority of the cases the projects cannot be completely justified, considering the recovery of the investments. Mechanisms of very long terms for financing are required and with mild interest rates as the used in projects of rural roads and aqueducts.

13. Operation, Maintenance and Repair

One of the most significative advantages of the hydroelectrical plants over the plants based on fuels, are the lower costs of operation, maintenance and repair, as well as the facility in the handling of the plant. The handling of the plant could be performed by local personnel with basic knowledges of mechanics and electricity and with a small training.

III. DEFINITION AND CLASSIFICATION

1. Tipification of the Small Hydroelectrical Plants

We consider necessary to classify the Small Hydroelectrical Plants according to diverse criteria, both concerning to technical parameters as to their application.

It is not useless to point out that the fall power limit magnitudes have only an approximate and reference character, being necessary to avoid excessive strict interpretations.

a) General Definition

A small hydroelectrical power station is a plant where hydraulic energy is used for generating small amounts of electricity starting from 5 Kw up to 5000 Kw appproximately, by means of one or more groups or units turbine/generator.

b) Classification as to Potential and Fall

A terminology which may permit a suitable differentation under a technological point of view is necessary to be adopted, and the following cirteria is taken by us:

		Fall (meters)		
	Potential Rank Kw	Low	Medium	High
Micro power plants	5-50	1.5-15	15-50	50-150
Mini power plants	50-500	2-20	20-100	100-250
	500-500	3-30	30-120	120-400

c) Classification as to application:

- Public and Private Lighting (including domestic appliances)
- Agriculture (pumping)
- Livestock
- Agroindustry (mills, concentrating plants, etc.)
- Small Industry and Craft (sawmills, mill-works, etc.)
- Services (maintenance workshops)
- Education
- Telecommunication

d) Classification as to the way of utilization

- Harnessing may be carried out at water surface (harnessing from a river) or with dam.
- The daily performance may be continuous or discontinuous.
- By its controlling it may be: regulatory (manual or automatic) or constant charge (the excess may be dissipated or being used in complementary applications).

e) Classification according to its connection with the electrical system:

They may be:

- Isolated Plants
- Plants integrated to small community networks
- Plants integrated to a national network
- Plants for isolated production centers (self-producers as the small mining, industry, agroindustry, etc.).

f) Classification as to its Technological Concept:

A general classification of these aspects is very difficult to work out, as they are meaningful mainly for each of the elements which constitute a plant; nevertheless, the following may be considered in a qualitative way:

- Plants with conventional technologies. Civil works of quality are considered at the water inlet, channel and loading chamber; extruder at the inlet, steel piping, electromechanical equipment designed and constructed as to standards of developed countries, broadly implemented panels, etc.
- Power houses with non-conventional technology. The utilization and improvement of inlets and existing irrigation channels, the load chamber fixed in line onto the channel and includes the extruder, pressure piping in non-metal materials, electromechanical equipment designed and constructed with appropiate technologies to the country's specific

conditions, modular simple panels with a minimum of implementation.

a) Pressure pipeline:
The following are considered among others:

- Polyethylene or PVC tubes are being used in some Latin American countries, with maximum diameters, around 305 mm. and suited for manometrical pressures of design of approximately 10 to 15 Kg/cm^2. This type of piping has the advantage of being extremely light, easy transportation, simple assembly and low cost. The polyethylene tube must be protected from solar radiation and impact.

- Asbestos/cement tubes may be used for low and medium pressures. They are not heavy and can be easily joined. Their transportation must be carried out with great care and be protected from possible impacts.

- Steel piping is the conventional way normally applied in hydroelectric power plants; standard pipes or welded tubes may be applied, according to sizes and availability of the country. The principal lenghts may be joined with standard connections, flanges or welding according to diameters, falls or particularities of

application.

- Reinforced concrete tubes can also be employed for obtaining a high resistance, and centrifugal construction which avoids leackage is utilized. Their assembly is easy and relatively economical in the steel use, cement and wood. They are practical for diameters greater than 500 mm. and for maximum manometrical pressures of around 20 Kg/cm^2. With great diameters these pipes must be fitted underground to avoid being affected by temperature changes.

- An advanced technology consists in the use of reinforced concrete prepared pneumatically, whose application in small hydroelectric power plants should be evaluated.

b) Turbine:

The type of turbine is selected according to the characteristics of the fall, water flow and spinning speed required. The specific speed (Ns) is the representative parameter defined as a revolving velocity of a reduced model with 1 meter fall and 1 CV.

The most usual models are:

- Pelton Turbine: is a rolling machine activated by a tangential flow, employed for relatively high falls, averaging between 50 and 400 meters. It is used with specific velocities in the rank of Ns. 10 to 25, incorporating a single nozzle and in a rank of Ns. from 25 to 50 with two nozzles.

- Its adjustment may be carried out manual or automatically, activating on the nozzle's needle or on a desviator of the flow. Combined forms are employed, depending on the size of the unit and conditions of operation.

  The Pelton Turbine has an excellent characteristic curve of efficiency which permits the operation to partial loads up to 25% without greater losses of efficiency.

- Michell - Banki Turbine:

  It is a transversal flow impulse machine in two stages on the roller. It is used for intermediate falls in the rank from 15 to 60 meters, and for specific velocities of around 30 Ns up to 120 Ns.

Its adjustment is carried out on a wiper in the injector, and its drive may be manual or automatic.

The characteristic curve of efficiency is similar to the Francis turbines. Its optimum performance is lower than the one reached with a Pelton turbine, although its construction is simple.

- Francis Turbine:
  It is a jet machine, used for intermediate falls in the rank of 15 to 20 meters, and for specific velocities applicable in small hydroelectric power plants, in the rank of 100 Ns. to 350 Ns.

  Its adjustment is carried out on distribution wipers annularly assembled, being activated manual or automatically.

  Its optimum efficiency is higher than the impulse piping, but its characteristic curve is not very flat, keeping high performances only to partial loads of around 40%.

- Kaplan and Helice Turbines:
  They are also reaction machines, employed for small falls of around 1.5 up to 20 mts. and greater flows, specific speeds of around 350 Ns. up to 800 Ns.

The adjustment of Kaplan turbines is performed varying the wickets angle together with the distribution wipers to the entrance, usually automatically.

Helice turbines are only adjusted by means of distribution wipers to the entrance and constitute a simpler and more economical solution, thus less efficient. The adjustment drive may be carried out manual or automatically.

The optimum efficiency of Kaplan turbines is the highest and its characteristic curve permits keeping high efficiencies up to 25% load. As regards Helice, they are highly efficient only in a narrow operational faction, maintaining its efficiency only up to 60% head.

Reaction turbines may incorporate a suction pipe which permits an additional good use of the fall.

c) Timing and Control:

In order to keep the correct speed of operation in the turbine, even when the head is variable, a pump controller is required.

In the very small units a controlling system with electric resistances may be used.

For the larger units, say up to 500 Kw, an oleo-mechanical controller is frequently used.

In the greater units, of 500 Kw, an electro-hydraulic pump controller is presently of very much use.

Electronic-mechanical pump controllers for small turbines are also being experimented with in Latin America.

The turbine should be a sluice gate valve at the water entrance, which must be closed in case of emergency (e. G. racing or heating of bearings).

d) Turbine-Generator Transmission System:

Direct coupling is employed when the turbine speed might get equal to the required speed for the generator. This constitutes the easiest transmission form.

When the turbine speed is less than the required by the generator and especially if standardizing turbine designs is required, the use of a speed transmission system to be employed is necessary, by means of belts for lower powers and gears for higher powers.

e) Generator and Electric Control:

In order to generate electricity taking advantage of mechanical energy produced by the turbine synchronous and asynchronous generators are used.

Synchronous generators or alternators are the most frequently used machines, which include a stirring up system and a voltage regulator. They enable to improve the power factor and have a high efficiency.

Asynchronous generators may be operated in parallel with alternators, and condensing systems are used in order to improve the power factor. It is worth pointing out that its efficiency is lower.

In Latin America the use of electric motors is also being experimented as asynchronous generators with a voltage regulator system and condensors for operating autonomously, applicable to lower powers.

The design of generators to be employed in small hydroelectric power stations must be suitable for resisting racing speeds for long periods.

f) Control Board and Instrumentation:

The electric control board is slightly different in synchronous and asynchronous plants. Some typical linear diagrams are shown in the annex.

The board must include the following:

- Control Instruments (voltage, current, power factor, frequency, etc.)
- Protection Units (low and high voltage, low and high frequency, asymmetric relay, etc.)
- Synchronization boards
- General Switch

g) Security:

The first point, in view of security of Small Hydroelectrical Plants, must be an appropiate design, in order that at least each part of the plant has a calculated duration of life not less than 200,000 operation hours. This equals 25 years period of continuous operation. Lower life periods may be considered if important reductions in costs of equipments are obtained, and replacement of components at low cost is assured.

The second point of security are electric and mechanical devices for protection, which should minimize damage risk to personnel or equipment, in any emergency case.

The third point of security is a periodical maintainance control, carried out by reliable persons.

It is indispensable to fix an earth-connection whose resistance should not be higher than 20 Ohms.

All metal machinery frames must be connected to an earth conductor.

It is necessary to have some regulations, assuring reliability of workmen at the time of installment, controlling electric assembly before energy supplying and everything disposed, in order that the users' assemblies do not have power factors that are too reduced.

h) Transformation, Transmission and Electric Distribution:

For low powers and short distances between the Plant and consumption places, generation and transmission at low tension is possible.

For distances and higher powers the most adequate voltage must be selected according to economical considerations and regulations in force in each country.

When feeding a national network, tension must be adopted to its own requirements.

IV. STRATEGY OF DEVELOPMENT

Although there are common characteristics for all the Latin American countries that allow the establishment of action guidelines for the development of Small Hydroelectrical Plants, it is not possible to precise many details considering the existing differences in our countries in regards to its hydraulic potential, level of economic-social development, population, etc.; consequently, it is indispensable that each country would establish its own strategy of development.

1. Planning and Programming of Development

We propose the following:

a) It is necessary that the countries will count with a planning unit in charge of the development of Small Hydroelectrical Plants.

b) It is necessary to count on a "Development Plan for Small Hydroelectrical Plants" at each country. Such plan should be closely linked to the Territory Organization in connection to the water utilization, especially with regard to the hydraulic development with agricultural purposes, potable water, etc. In the development plan for Small Hydroelectrical Plants, actions should be projected in short, medium and long terms, with the corresponding priority and the following aspects should be considered among others:

- Global evaluation of the electrical demand of the universe of the rural isolated populations, based on the existing stadistics; detailed evaluation based on the significative samples in the basins that are under study.

- Evaluation of basins and statistical analysis of the hydroenergetic potential in small scale.

- Substitutive studies and complementary studies of the renewable energy alternative sources.

- In the development programs of irrigation and channels, the hydroenergetic utilization in small scale should be considered.

- Strategy of Development of the Technology for equipment and materials, in coordination with the entities responsible for the technological research.

- Policies of technology acquisition.

- Policies of equipment acquisition.

- Institutional policy and enterprise schemes for small hydroelectrical plants.

- Policies of captation of resources for the investment.

- Financing policies; priorities.

- Criteria on projects evaluation.

- Requirements for the elaboration of studies.

- Tarrif Policies.

c) It is recommended the preparation of biennial programs of development of specific projects each year, including the evaluation of the performance of the program corresponding to the last year. These programs must be elaborated by the entities responsible of the coordination and execution of the projects.

2. Legal and Institutional Aspects

In Latin America we find State,Mixed, and Private schemes in the electrification enterprises, being predominant the state enterprises.

In many countries the State Monopoly of the electricity, under different forms of centralization and discentralization, has given positive results in the development of the electrification. Nevertheless, it is frequent to face organization problems and high investment and operation costs when the centralized scheme is applied in a strict form for the development of small hydroelectrical plants.

Although the legal and institutional forms would have to depend on the government policies of each country, it is possible to suggest mixed organization forms that will combine the participation of the state electrification enterprises with cooperative organizations -communal and municipal- in the case of intermediate capacities as for example of 500 - 5000 Kw.

For smaller potentials, say up to 500 Kw., the formation of municipal enterprises, cooperative and original communities could be considered, with servicing contracts with the electrification entities (projects, maintenance, operators training, etc.).

We should emphasize on the importance of the participation of the rural population in the execution of projects of small hydroelectrical plants, in organizative schemes that are flexible and will permit the State to grant the management and technical assistance, funds and equipment, while the rural population will take the iniciative of facilitating the necessary manpower, some materials such as the ones added to concrete and the transportation of materials and equipment.

The principal advantages of establishing institutional means that will permit the participation of communal and municipal organizations are:

- Reduction of apparent investments by enlarging to the maximum the local participation in the project.

- Better conditions to overcome the conflicts in the utilization of the water with irrigation and generation purposes.

- Possibility of giving discounts in the tarrif as reimbursement of the individual contributions in the execution of the work (manpower, lending of animals, materials, tools, etc.) that will allow to impel the cooperation of all the members of the community.

- Major facilities for inspection and control of the installed capacity of consumption, considering that in many cases electric gagers will not be used.

- Less costs of operation by using operators contracted locally.

Nevertheless, some limitations that should be overcomed, have to be also considered, such as:

- Small qualification of local manpower that contributes in the project.

- Unequal reasons among the Members of the community to collaborate in the project.

- Difficulties to comply with the execution terms of the works; the planning of the execution must be careful. It is necessary to consider the limitations and the availability of local manpower during the periods of sowing and harvesting.

- Small administrative and enterprise experience in the operation of the plant.

- Necessity of an intensive program of qualification of local operators.

- Small knowledge of the rural population of the benefits that could derive from the energy development. It is necessary to make diffusive campaigns.

On the other hand, it has also been observed that in the majority of the Latin American countries the legal procedures over the utilization of the water with energy purposes do not have a sponsoring characteristic and the authorization criteria do not change in a big scale according to the different sizes of the projects. Likewise, the administrative procedures are very slow and annoying, becoming, very probably, one of the principal obstacles for the execution of projects. It is recommended to adopt the legal procedures to the different cases that could be presented, giving special facilities whenever concerns to small potentials and when the users of the energy are the same users of the water with agricultural purposes.

3. Evaluation of the Hydroenergetic Resources in Small Scale and Demand of the Rural Populations

The major part of the Latin American countries are developing evaluation programs of their hydroenergetic resources, but always emphasizing the evaluation of the utilizable potential in a big scale.

It is convenient to impel programs of evaluation of hydroenergetic utilizable resources in small scale, taking in consideration the following:

- To establish evaluation priorities by basins, considering the importance of the hydraulic resource as well as the populative characteristics and the economic and social characteristics of the zone, taking into consideration that the electrical energy will normally be used in that same zone, without integrating interconnected systems.

- In a first stage, the evaluation of the hydroenergetic resources will not always be precise, identifying specific projects, but, in a certain measure it must have an statistical characteristic.

- The evaluation of the resource must be associated to the devaluation of the demand located in the villages of the zone, establishing comparisons of projection of demand, verified through significative samples and identifying groups of towns that could be eventually attended with a small system of generation of medium tension, say 10 Kw., and an isolated town that can only be attended with a small low tension plant.

- Considering the previous point, it will be necessary to proceed with the identification and approximate evaluation of the specific projects, locating possible falls and approximate measurements of flows.

- For the preliminary evaluation of the projects, approximate measuring methods could be used, such as altimeters or leveling systems through cables and levels and for the establishment of the falls. In the approximate measuring of the flows could be used simple floatation devices or pin-wheels and spillways.

In the majority of the cases we will count with the historic information of river gagings and slippages, etc., consequently, local polls and visual inspections should be performed for the preliminary selection of the locations.

- The programs of short term investments will be independant from the global evaluation projects of resource and demand, with the purpose of not delaying the execution of prioritary projects.

- The global evaluations of the resource must include geological and geomorphological studies that will constitue useful references for the identification of specific projects. Nevertheless, in the preliminar evaluation of such projects, it would not be convenient to exaggerate the emphasis over the detailed geological studies, but to be restricted to qualifying evaluations.

- In the evaluation of the hydraulic resource other utilizations of the water -especially the irrigation- should be considered with the purpose of establishing complementation criteria with the energy development.

- The characteristics of the existing irrigation channels should also be evaluated, as well as theirpossibilities of improvement and enlargement and their possibilities

and limitations for the combined utilization with generation purposes.

4. Technology and Equipment Supply

The situation of the Latin American countries in regards to technology and equipment supply is very changeable, depending on the relative level of industrial development of each country, their technologic policies, the efforts performed in the research and development of them, as well as the industrial experience acquired in the manufacturing of equipment.

Depending on their own policies at each country, we consider in first place to emphasize the technological programs of reserach, to develop the designing technology and manufacturing of equipment, according to the conditions and possibilities of each country.

In second place, when the technological development in certain types and sizes of equipment do not result changeable, the acquisition of the technology that will permit the industrial implementation of the equipment should be considered.

In third place, in the cases where it is not feasible the production of equipment, the acquisition of such equipment must be considered.

In all three cases, it is necessary to establish a mechanism of coordination and cooperation among the Latin American countries, with the purpose of securing a regular supply of equipment of regional origin.

a) Technological Research and Development

Based on the possibilities and technological policies of each country, we consider highly prioritary to develop a technological research program over small hydroelectrical plants, due to the following reasons:

- It will permit to improve to a maximum the possibilities of developing design technologies and of manufacturing equipment suitable to the specific conditions of the country.

- Production of equipment at low cost, which will permit a reduction of the initial investments.

- The design of equipment that could be adequated to the locally obtained materials and to the industrial productive structure of the country.

- Development of non-conventional technologies.

- Systematic development of the technical knowledge and gathering of the relevant information.

- Intensive and systematic preparation of specialists.

- Generation of experimental infrastructure and capacity to evaluate operating plants.

- Better capacity to evaluate the alternatives for the acquisition of equipment.

- Big financial resources are not needed to start the investigation.

It is not possible to establish a unique pattern for the establishment of Technological Research Programs over Small Hydroelectrical Plants at each country. Nevertheless, some general points can be outlined and their application must be considered, in each case, as indicated as follows:

- It is necessary that each country will count with defined policies of technological development, which must be the frame for the priorities of the technological research of the equipment for the Small Hydroelectrical Plants.

- It is necessary to define the type of institution that should be in charge of the execution of the technological development of equipment. It could be an Institute of Technological Industrial Research of the State, the universities, research organizations of the entities in charge of the execution of investment projects in small hydroelectrical plants or industrial enterprises dedicated to the manufacturing of equipment.

- A feasible scheme in many cases consists in giving the responsibility to the State Institute of Research, which executes

directly some aspects of the research and contracts or entrusts the specific aspects of the research, to be developed, to universities, that count with qualified researchers and with an experimental infrastructure; and to enterprises that manufacture equipment for small plants or similar products, which are capable to be in charge of research tasks directed to theirindustrial implementation.

- The captation of financial resources for the research depends on the institutional structure to be adopted, in a great measure, with the purpose of guaranteeing the correct use of the funds which could be of public origin, taxes of industrial enterprises dedicated to finance research activities that could be retained by the same enterprises if they perform research activities, international technical assistance and resources of investment projects directed to finance pilot plants in practical applications of electrification.

- The international technical assistance that could be obtained and its effective utilization are also conditioned to the institutional structure of technological research to be adopted, with the purpose of securing the effective economic opposite entries and the qualified technical counterparts, capable of utilizing the external contributions.

Special attention and care should be given to the definition of the objectives and extent of the program, whenever is related to bilateral technical cooperation, with the purpose of avoiding obscure forms of selling of technology conditioned to the commercial objectives. In case such forms are needed they should correspond to clear actions of negotiation of selling of technology under favourable conditions and not to an exclusive licence covered behind a program of assistance. Likewise, on all the cases of the international technical assistance, must be clearly established all the mechanisms of effective captation of the knowledge.

In performing the technical assistance programs, the following aspects should be taken into consideration:

Remittance of the technical information.

Contracting of foreign experts, principally the specialists.

Supply of instruments and laboratory equipments.

Financing of the local manufacturing of prototypes.

Granting of specialization schoolarships.

- It is necessary a close coordination between the institution responsible for the technological research and the entities in charge of the planning and development of investment programs, with the purpose of:

1) To secure the maintenance of practical and feasible objectives of research.

2) To avoid the transformation of the research process into an obstacle to the development of investment projects that should continue with the available technologies.

3) To overcome the intermediate stage between the finishing of the technological research and its experimental application controlled in certain investment projects.

4) To secure effective and fast channels for the practical application of the technologies that are satisfactorily developed.

5) Technical assistance of the reserach equipment should be given to solve specific technological problems in investment projects.

6) To supply referential technical information to the institution that performs the technological research.

7) To secure the technical collaboration of the institution that develops the reserach program in the evaluation of the cases that need to acquire technology and in the evaluation of the acquisition of imported equipment.

- To develop technologies that could be adapted to the productive industrial potential of the country, securing that their implementation will be feasible.

- The technical reserach of the equipment must consider the following procedures of action for each project:

1) Gathering of information.

2) Formulation of the research project.

3) Financing of the project.

4) Forming of the research group and the distribution or entrustment of the research aspects to other entities.

5) Basic analysis, theorical principles and design methodologies.

6) Definition of the experimental attainments (laboratory and/or pilot plant).

7) Design and construction of prototypes.

8) Test and experimentation of prototypes; corrections.

9) Feedback and correction of design methodologies.

10) Elaboration of designs of details of industrial series of the equipment, including lists of materials and manufacturing methods, also considering the criteria on standarization and interchange of components.

11) Practical and controlled application of the developed technology in investment projects.

12) Implementation of the industrial production of the equipment.

- The developed technology must be directed to the simplification of the installation, start and operation of the equipment, in such a form, that it could be adapted to the participation of the local communities in the projects.

- Adequate equipment to function under unfavourable situations must be developed regarding the maintenance as well as the operation of such.

- The efficiency of the equipment which technology is developed, should be as high as possible, with the purpose of securing an adequate economy of the hydraulic resource, reasonable sizes and costs of the equipment and trustable functioning, whenever the major efficiency depends on a good design and could allow to obtain the maximum utilization of local materials; and whenever the design is adequated to the development level of the producing capacity of the country and allows the production of equipment at a low cost. In these cases it could be necessary to sacrifize the best utilization of them to their best efficiency.

- It is convenient to initiate the development of the technical research for low potential

applications, say 5-50 Kw., to secure a process of acquisition of experience and knowledge with less financial and technical risks. According to the advance and experience obtained, it is necessary to guide the research works to major potentials, such as 50-500 Kw. and later on to the 500-5000 Kw. level.

Regarding the type of falls to be considered in the development of specific technologies of the equipment and materials, such must be decided according to the own nature of the hydraulic resources that predominate in the country and to the priorities of energy development, for instance in a mountainous country with limited water flows, the development of turbines of low specific velocity will be prioritary; in countries with plains and abundant hydraulic resources with small falls, the development of turbines of specific high velocity must be priorized.

- According to the policies of industrial development of each country and to the size of their investment programs in small hydroelectrical plants, the equipment considered necessary for the technological development must be selected. Some specific lines of research that could be considered are indicated as follows:

- Gates, grids, valves.

- Pressure tubings, non-metalic alternatives such as PVC, Polyethelene, asbestos-cement,

wood, etc.

- Hydraulic turbines.

- Transmission systems, turbine/generator (for low potential)

- Speed controllers for turbines (oil-mechanical, electric-electronical).

- Synchronous alternators, excitation systems, voltage controllers.

- Asynchronous generators, condensors, voltage controllers.

- Security devices against racing.

- Instrumentation and operation panels of modular and standard type.

- Lightning protector.

- Low and high tension lines; wood poles locally obtained and other types.

- Also should be considered under the technological research the following aspects referred to civil and hydraulic works:

- Typical designs of inlets and captation systems.

- Calculation and design of channels, study of multiple utilization for irrigation purposes.

- Typical desings of loading chambers.

- Designs of excluders in the inlets and/or the loading chambers.

- Design and calculation of grapplings and tubing holders.

- Methodology of installation of tubings and equipment

- Typical designs of power houses.

- The following should be a complementary part of the technological research work:

- Elaboration of preliminary evaluation handbooks for the projects, accesible to non-specialized persons.

- Elaboration of handbooks of the project and design of small hydroelectrical plants.

- Models of electrical service regulations for communal management.

- Operational and maintenance manuals for operators.

b) Transference of Technology

We refer principally to the selling schemes of manufacturing technology of equipment, under the licence granting methods.

Whenever a country does not consider prioritary the technical development of certain equipment or sizes of equipment, or whenever the works of research do not present possibilities of implementation in smaller terms to the required ones for the development of the industrial production of equipment, an adequate option is the acquisition of technology which should be performed through a careful process of evaluation and selection of alternatives and considering, among others, the following criteria:

- It is recommendable to count with various alternative proposals of selling of technology, obtained under the same referential terms and evaluating such with highly considered pre-established criteria.

- The selling contracts of technology must have fixed terms of duration, from which the obligations for paying royalties will terminate.

- The royalties must be established over a percentage of the sells, avoiding the inclusion of restrictive clauses in regards to guaranteeing minimum yearly payments.

- It is not convenient to accept restrictions in relation to the market scope to locate these products.

- The appropriate technologies for the productive structure of the country must be favourably considered, as well as their local conditions of utilization.

- It is not recommendable to accept restrictive clauses regarding the integration of the local manufacturing components and consequently obligations to import parts and pieces.

- The technical assistance must be part of the process of transference of technology and must be directed, especially, to the training of personnel at the country that needs it.

- It is convenient that the governments will define clear policies of acquisition of technology that will re-enforce the capacity of negotiation of the local enterprises for the transference of technology.

- It must be considered that the acquisition of the technology is justified, especially for the acquisition of equipment of a larger size of complexity that will be over the potential of development of self-technology.

- The technological package to be acquired must be separated and restricted from those elements that are necessary, avoiding the inclusion of elements that could be designed and manufactured locally without external help.

c) Acquisition of Equipments

Under certain circumstances, it is necessary to import equipment, whenever their sizes or characteristics are over the productive capacity of the country; for this case, the following are some considerations that should be taken into account besides the conventional criteria in relation to the fulfillment of technical specifications, prices and terms of payment:

- In the technical evaluation of the proposal factors such as manufacturing capacity, local repair of components and spare parts, characteristics of maintenance and operation suitable to the application conditions, ability to overcome situations derived from operation mistakes, assembling facilities, etc., should be considered.

- The acquired equipments must include detailed construction plans and lists of materials with the purpose of facilitating the assembling, disassembling and repair.

- It is necessary to count on technical boards and adequate groups to make admittance tests. The institution dedicated to the technological research could help in this purpose.

- The technical assistance must be directed especially to the training of local personnel.

5. Elaboration of Studies

The required studies for a specific investment

project constitute one of the aspects that characterize the difference between the small hydraulic plants and those of larger sizes.

Frequently, in Latin America, formal criteria are adopted in regards to the elaboration of studies which are as follows:

- High costs of studies; sometimes they reach up to 30% of the investment; small relationship between the size of the studies and the importance of the project.

- Excessive data processing from information based on insufficient bases, in the hydrologic aspects as well as geologic, tophographic, design in detail of works, electrical demand, etc.

- Terms of reference excesively formal and rigid for the elaboration of the studies.

- Small value to the studies as effective guidelines for the execution of projects; lack of realism.

- To give a sense of urgency to the chronograms of execution of projects.

- Lack of technical manuals to make the elaboration of studies more accessible.

- Hard selection of proper consultants.

The requirements for the studies are different in the case of small potential, lets say lower than 50 Kw., than the ones of major potential, for instance over 500 Kw. Likewise, the conditions change from country to country depending on the basical information available and on the margins of risk that are taken. Nevertheless, some recommendations, which application should be evaluated for the proper conditions of each country, are the following:

- The preliminary evaluations for small projects should be performed based on the gathering of existing informations in elemental systems of measuring of flows and available falls; visual recognizing of the ground and polls done to the local population to obtain the historic evaluation of the resource; antecedents of floods and slides; possibilities of agro-industrial development; services and requirements of illumination.

- Once a project is evaluated, priorized and programmed, contacts and agreements should be established with the local inhabitants to secure their participation in the execution of the project.

- The pre-feasibility studies must be considered only in the cases where the importance of the investments will justify this and whenever there are alternative options that should be analized.

- The deep analysis of the feasibility studies must be related to the importance and characteristics of the project. The precision in the studies must be fomented by avoiding the negative ritual of excesive extension of the text.

- The studies of detailed engineering of the project could be part of the feasibility study, whenever exists a decision of execution of the project and whenever there is availability of the sufficient previous information, taking into consideration the following:

1) The hydrologic studies must have an integral characteristic in a determinated basin; it will be difficult to justify them for a specific project.

2) The studies of soils mechanics are justified for major works and whenever there is uncertainty and important risks, on the contrary, only excavations and visual evaluations of the ground should be done.

3) The utilization of basic modular designs must be emphasized, adapted to specific conditions.

4) The topographic survey and leveling must be restricted to the areas of major interest and in the case of the smaller plants could be omitted completely, except in the precise areas (inlet, bucket, etc.) and in the handmade

methods of profile outlining.

5) The possibilities of using and adapting the existing works such as handmade inlets and channels, should be considered, designing and specifying the improvements to be performed in an understandable way to an experienced foreman.

6) Wherever applicable, it is convenient to specify the utilization of simple concrete to reduce the investments.

7) To consider in the design the modalities of transportation of materials and the level of mechanization of the works.

8) To consider with priority the use of tubings of non-conventional materials (PVC, polyethelene, asbestos-cement, etc.) to reduce the investments. In some cases, as in the use of tubes of polyethelene, the detailed survey of the profile falls and location of the grappling is not significative.

9) To consider modular forms semi-standarized for the design of the power house.

10) To consider the minimum facilities for the mechanical and electrical local maintenance and resistance of the operator.

- A careful evaluation by consultants is needed; for the smaller potential the elaboration of projects by professionals must be emphasized -not necessarily specialized- being necessary for this to issue appropiate manuals.

- The responsible entities for the electrification projects must have a self-capacity of elaboration of studies, this will permit to also have a better capability to evaluate the contracted studies.

6. Construction, Installation and Start of Operation

The characteristics of the execution of the works and start of operation vary enormeously, depending on the importance of the project, characteristics of the ground, avialability of materials locally, access and distance of transportation facilities to and from the zone, capacity and experience of the technical boards, availability of local manpower, institutional forms and engagements for the execution of the project with the community organizations, availability of mechanical equipment and employment policies.

Notwithstanding what is mentioned above, the following are some general points that should be considered:

- Depending on the costs structure, the intensive use of local manpower in the execution of the works should be propitiated.

- The use of materials that could be obtained in the zone, such as sand, stone, wood, etc., must be emphasized.

- The chronogram of execution of the works must be studied carefully, taking in consideration the periodical requirements of manpower originated due to the agriculture, but without sacrificing the objective of an accelerated execution.

- The transporation of materials must be carefully planned, the utilization of beasts requires a good knowledge of the working rythms that could be applied, the preparation of the pathways and the circulation of the load without interferencies is very important, especially in the mountainous zones.

- For the security of the personnel the basic conditions of their qualification and experience must be considered; the use of adequate materials and equipment that will be a warranty of utilization should be taken in consideration.

- For the participation of the local communities in the works, the formation of groups or brigades of work should be considered, establishing goals and estimulating the emulation.

- The local training of manpower for construction and carpintering work contribute to a better execution of the work and the raising of the employment qualifications of the population.

- The engineering designs will have to be complemented or corrected frequently during the execution of the work. Consequently, the experience of the foreman or the job supervisor is essential. The opinion of the local inhabitants is very useful in the modifications that will depend, especially, on the ground.

- It is important to take in consideration that the presence of technicians and workers, that are non-qualified, at location, during the execution of the work, will create particular socio-economic situations that could have positive aspects in regards to the cultural and social interchange, but they could also generate negative situations when the foreign personnel does not get adapted to the local habits, or problems in the behaviour are generated.

- The final decision of adaptation or improvement of the existing works such as inlets and channels, should be given through the visual recognizing of the ground and by gathering information locally.

- The installation of the equipment normally requires qualified personnel, nevertheless, it is convenient to involucrate in the work all those inhabitantes of the location that could be trained as operators, with the purpose of making them familiar with the equipment and installations.

- The operators designated, of local origin, must participate from the initiation of the operation of the plant.

- The approval tests of the plant must be standarized under established protocols, according to the types and sizes of the plants.

7. Operation and Maintenance

Depending on the type of equipment, size of the plant and structure of the enterprise of electrical service, the following is recommended to be considered:

- The utilization of operators that come from the location zone where the plant is installed must be considered preferable, since the incorporation of operators of foreign origin to the location increases considerably the costs of operation, also there are problems for them to stay at the location and frequent difficulties of social adaptation.

- The utilization of non-experienced operators from the location is not recommended since this creates high risks in personnel security, conservation of the equipment and continuity of the service.

- The development of training courses for the local operators is recommended, including subjects referent to operation, emergency actions, security, elements of preventive electromechanical maintenance, small repairs, electrical installations, practices of bed river mechanics, inspections, reading of instruments, tarrifs, etc.

- It is convenient that in the small hydroelectrical plants are considered the living quarters for the operator and a basic bed river mechanical shop and electrical installations, to obtain a bigger employing stability, better maintenance, an additional source of income for the operator for the performance of different services in the community and principally, to secure a point of penetration and technological advance in the rural media, around the small hydroelectrical plant.

- In case appropriate technologies of equipping have been adopted, that will permit the standardization and interchange of components, it is possible to secure an adequate supply of spare parts with a minimum stock.

- It is indispensable to count with operation manuals and maintenance manuals that could be clearly understood by the operator.

- It is recommended to train one or two principal operators and few assistants.

- Frequently, while there is not producing activity, the use of the plant has an essentially nocturnal characteristic; consequently, it is urgent to promote such activities to raise the profitability of the plant and to enlarge its social-economical impact.

8. Investments and Operative Costs

The initial investment per installed kilowatt in the small hydroelectrical plant is generally high and tends to grow while the size of the plant is smaller, the high investments determine that the principal operation costs are the amortization and the interests. For this reason, the feasibility to develop construction programs of small hydroelectrical plants is linked to the reduction of the required investments.

Consequently, it is convenient to take in consideration the following:

- The technological development must be directed to the design of equipment at a lower cost, especially for low potential,

even sacrificing expectatives of useful life of some components which replacement must be at a low cost.

- The defficiencies in the quality of the equipment could increase the operating costs.

- The simplification and relative standarization of the civil works permit important savings in the investment.

- The adaptation of existing works (inlet and channel) permits to reduce the magnitude of the works.

- The use of non-conventional material in the tubings reduces the investments.

- The unitary cost of a small hydroelectrical plant could vary between US$ 800 and US$ 3,000 per Kw. installed, depending on the capacity of the plant, the used technology, the characteristics of the ground and its accessibility, the magnitude of the work and the contribution of locally supplied manpower that is not contabilized in the investments.

9. Financing and Recovery of the Investments

The following aspects are recommended to be considered:

- It is important to make a difference between the nature and the objective of the specific investment projects, since the same criteria to finance projects of promotional type related to the rural electrification must not be used, but the one used in projects that have an initial direction toward the productive activities (agro-industry, small mining, etc.). For the first case, the payment of the financing cannot be expected from the profitability of the project; consequently, the state must assume a considerable part of the investment without any perspectives of return. The second case is only justified by the profitability frame of the integral project.

- The tied credits frequently include technological conditions and of the origin of the equipment. In small magnitude projects, they frequently determine an excessive increase in the investments.

- The entities of financing development frequently handle the projects of small hydroelectrical plants in a similar way to major projects; it is necessary to develop faster schemes and less formality in the preparation of the studies; there are some positive experiences at a regional level in which the feasibility is based on a significative sample of projects that form part of a wider group.

- It will be convenient to consider, in parallel to the financing of wide construction programs, the obtaintion of funds for technical assistance that are non-reimbursable, for research projects directed to support the investments program.

- It is convenient to consider prioritarily the locations that have a productive potential that could be easily promoted to increase the electrical demand. It is important to point out that in the rural area, the domestic and public consumptions have a fundamental evening characteristic. Consequently, the development of productive activities improves the level of utilization of the installed capacity. The contrary is also valid, in other words, wherever the installation of a small plant is considered, it is convenient to promote the development of productive activities that will take advantage of the energy availability.

10. Latin American Regional Cooperation and OLADE's Role

We consider that there are the best conditions in Latin America for the development of small hydro-electrical plants, due to:

- Abundant hydraulic resources that could be used in small scale.

- A big number of rural isolated towns with a reduced number of inhabitants, with big distances among each other and accidental geography.

- There is adequate capacity and planning, and programming experience that could be applied to intensive programs of development of small hydroelectrical plants.

- There is infrastructure and capacity for technological research and development of equipment suitable to certain conditions.

- There is capacity of equipment production and some lines of production developed since many years ago.

- There are regional and sub-regional organisms that could contribute to a wider cooperation among the Latin American countries, such as OLADE, ALALC, the Andean Pact, etc.

- The potential market is wide enough to keep the self-supply of equipment of Latin American origin.

Within this context, OLADE has foreseen to initiate an integral program of development of small hydroelectrical plants in Latin America, starting from the fundamental basis that the program will be supported by the cooperation among the Latin American countries in its different aspects, such as planning and programming, technology, supply of equipment, elaboration of projects, etc..To do this we look forward to count with the support of entities of international cooperation that have interest to collaborate in a program of this kind.

In reference to the method, we hope to perform an effort of articulation, integration, complementation and support of the actions that the Latin American countries are performing, unfolding the program in two fronts of action:

a) Technology, Equipment and Materials

These include actions of research and development of technology, transference of technology, acquisition of equipment, availability of materials and capacity of equipment production, materials and components, elaboration of manuals of the project, experimental capacity and interchange of information.

b) Energy Development through Small Hydroelectrical Plants

This includes general planning actions, evaluation of resources and demand, development programs at short terms, financing sources and conditions, elaboration of studies for specific projects. Construction, start of operations, operation and maintenance of Small Hydroelectrical Plants. Training, institutional aspects, organizative aspects and enterprise aspects related to the service.

Depending on the decisions to be taken by the corresponding levels, the Council of Experts and the Meeting of Ministers, this program will be initiated during the year 1980.

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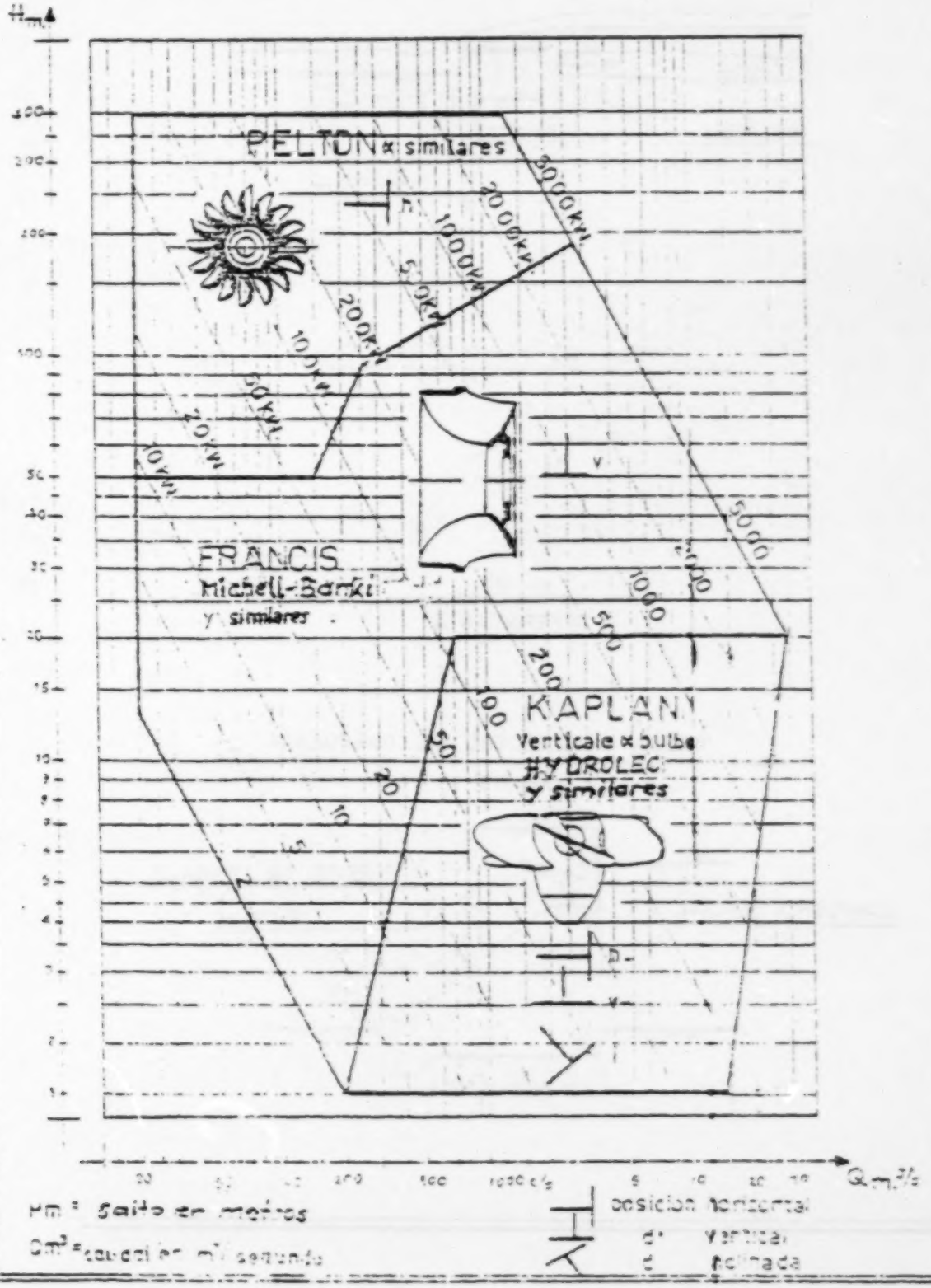

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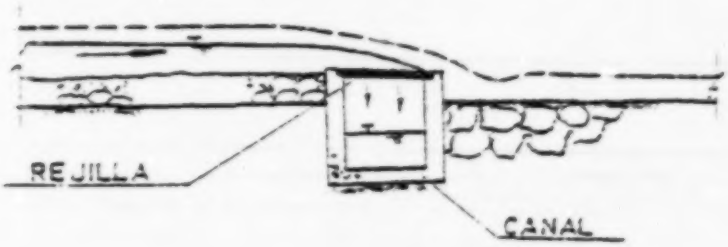

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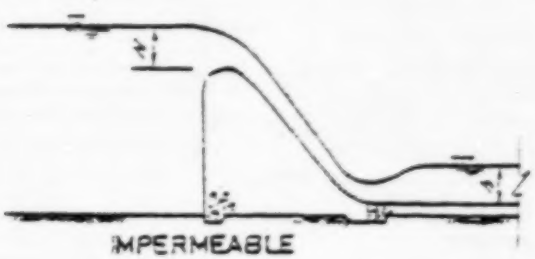

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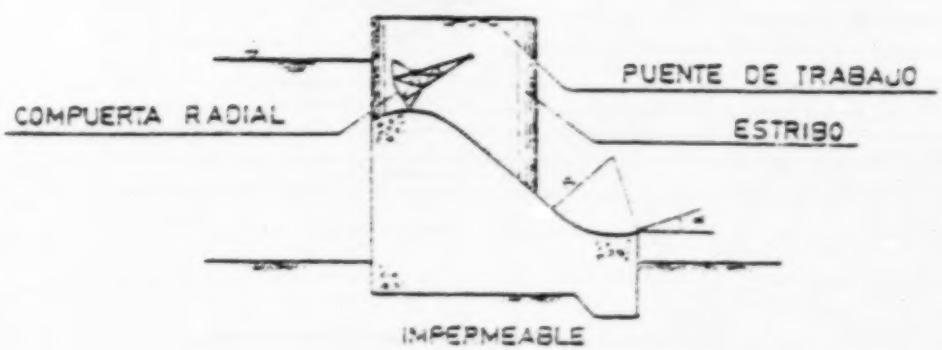

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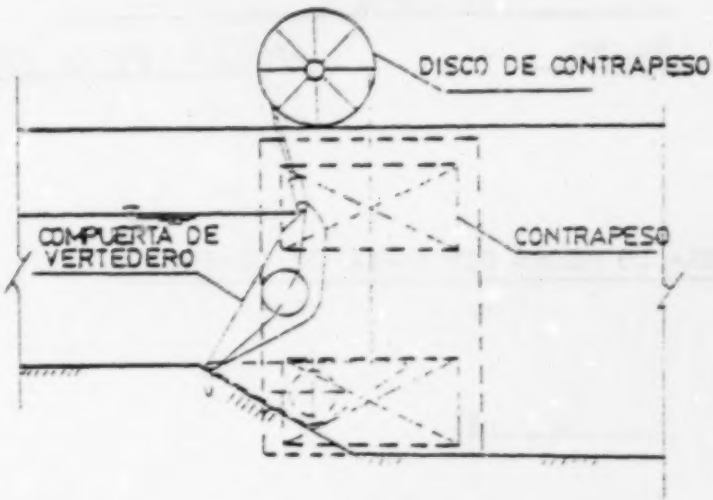

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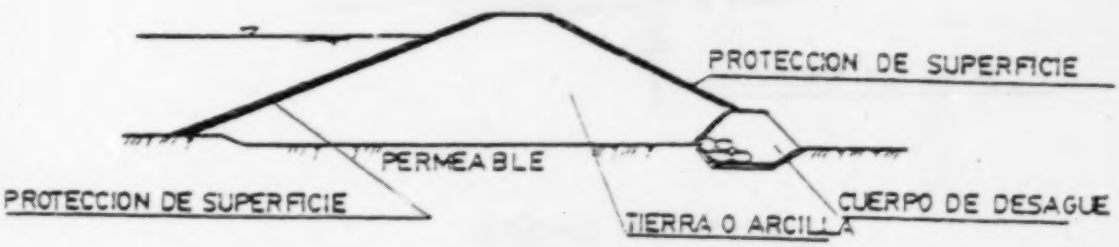

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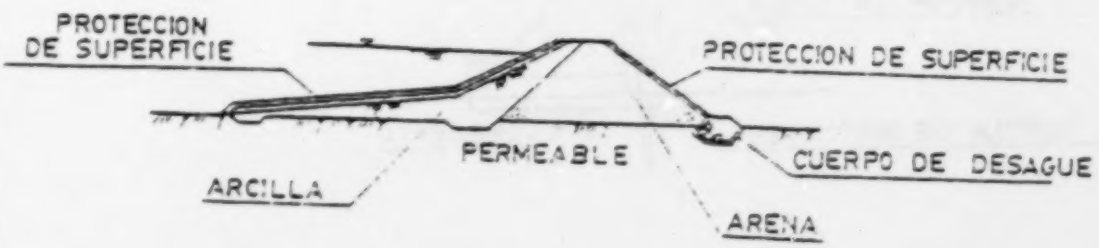

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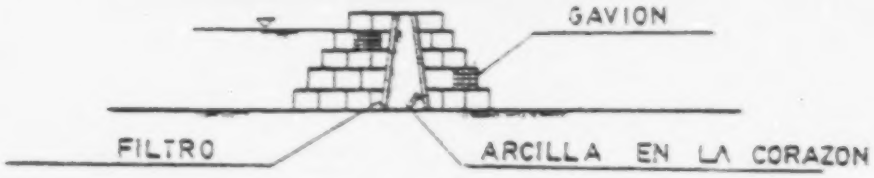

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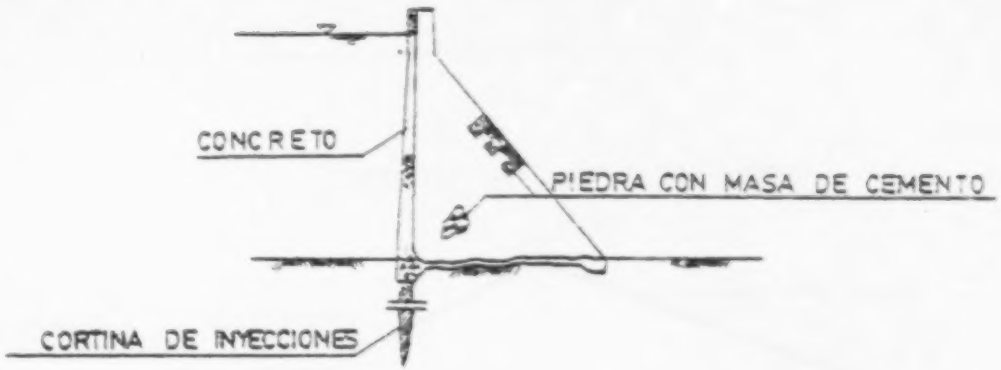

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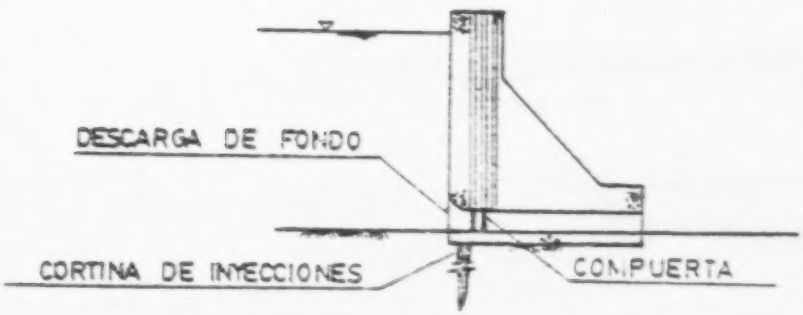

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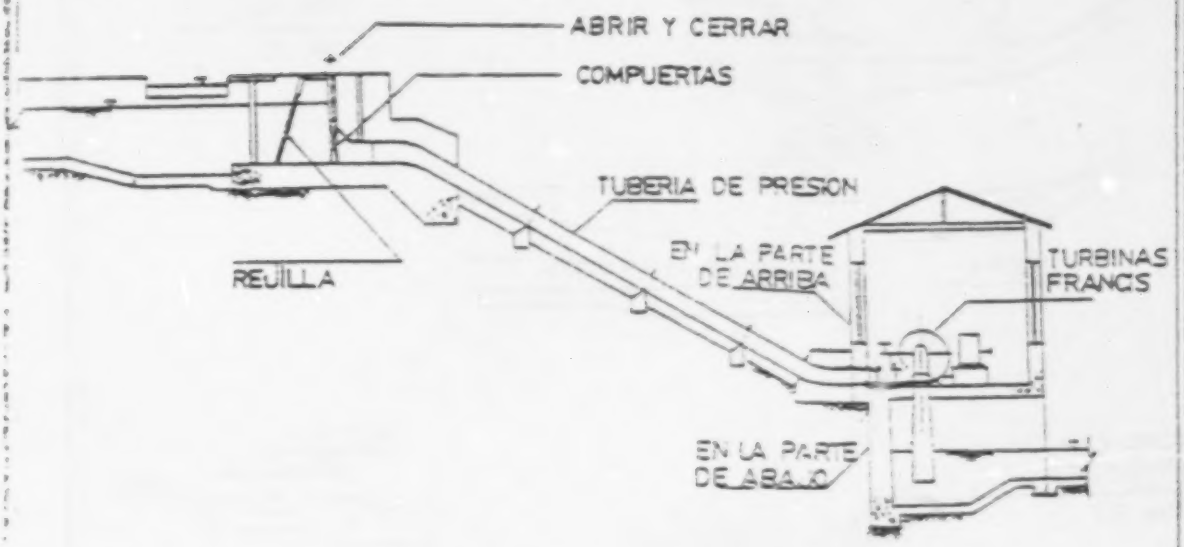

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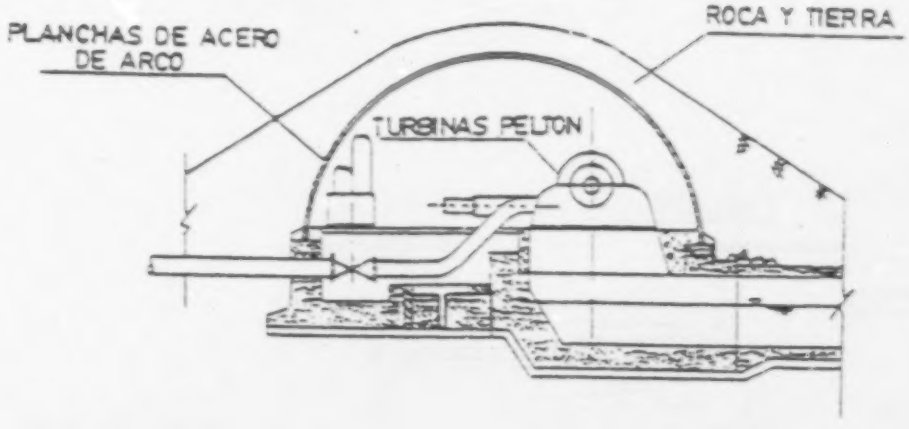

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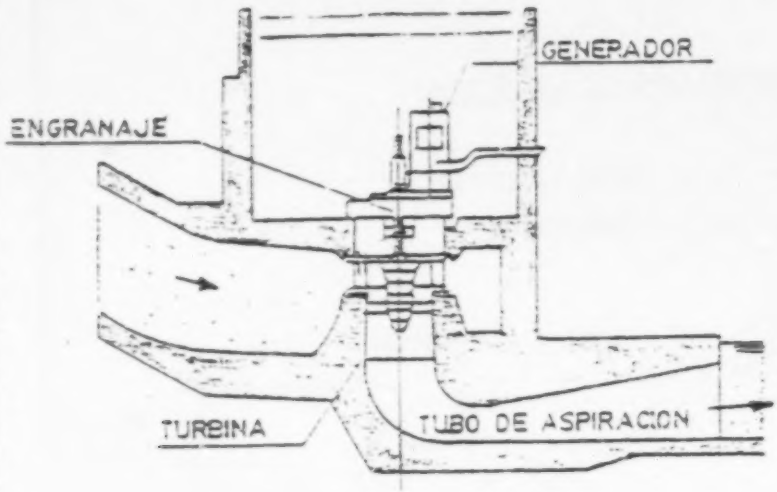

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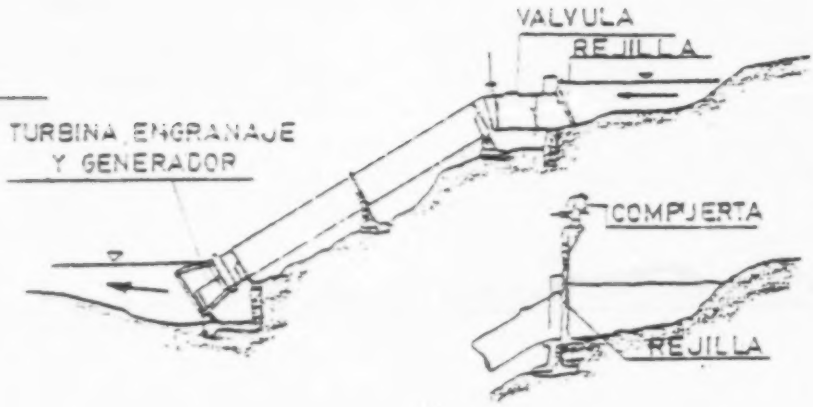
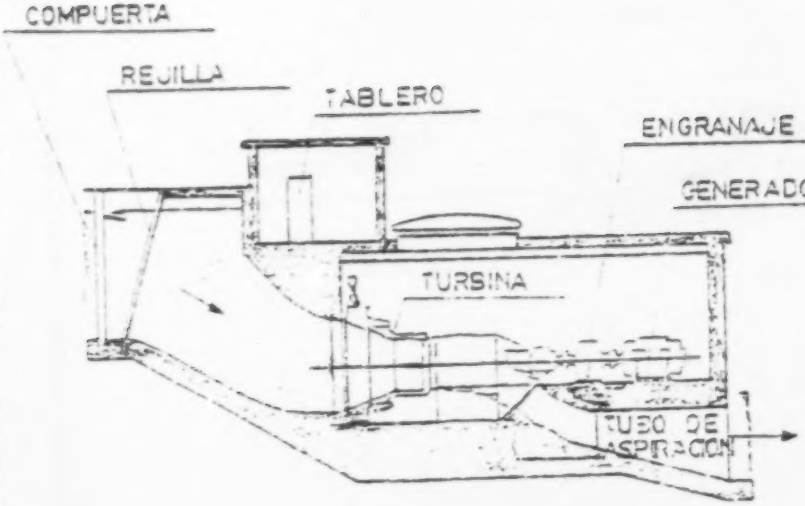
No. 3.2

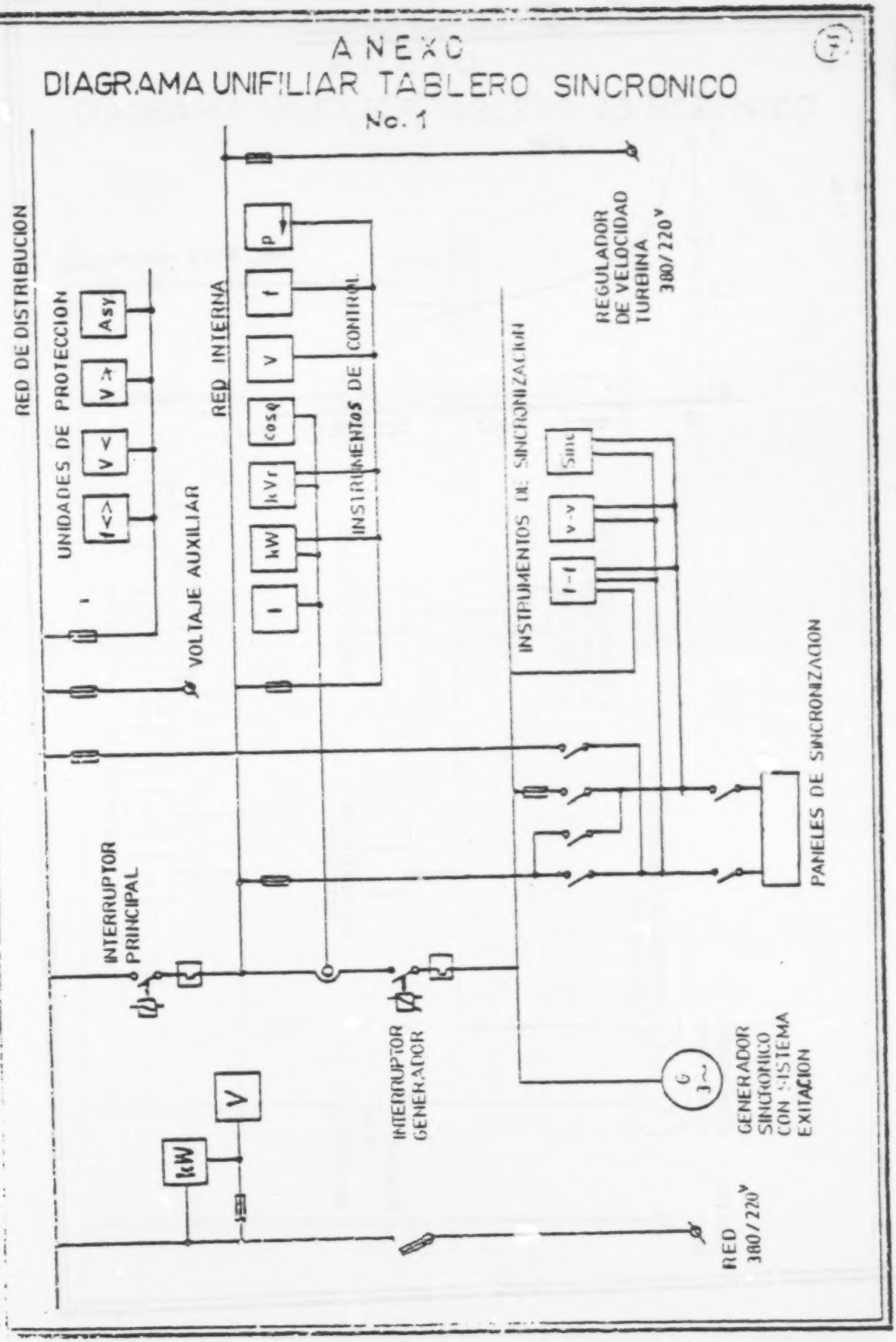




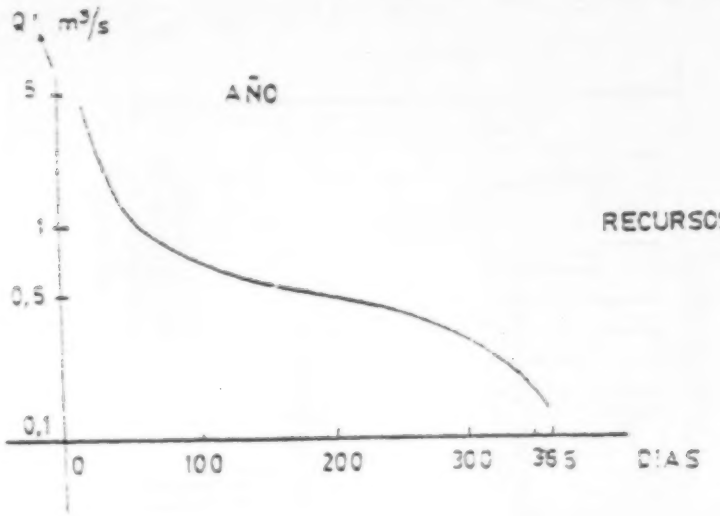
GRUPO KAPLAN HORIZONTAL (BULBO)

No. 3,3

ANEXO
DIAGRAMA UNIFILIAR TABLERO SINCRONICO
No. 1



CAUDALES CLASIFICADOS



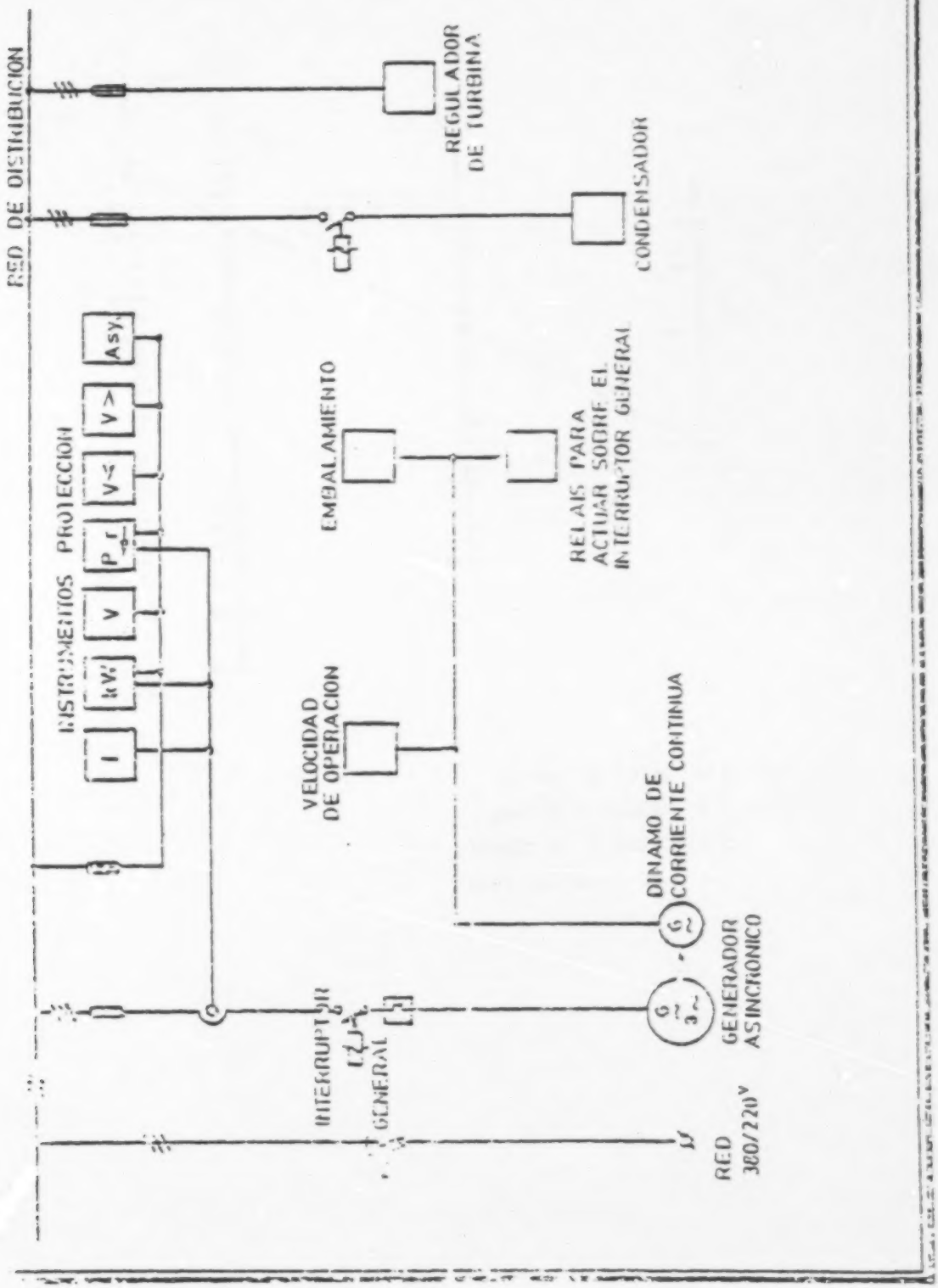
No. 8

RECURSOS NATURALES

ANEXO

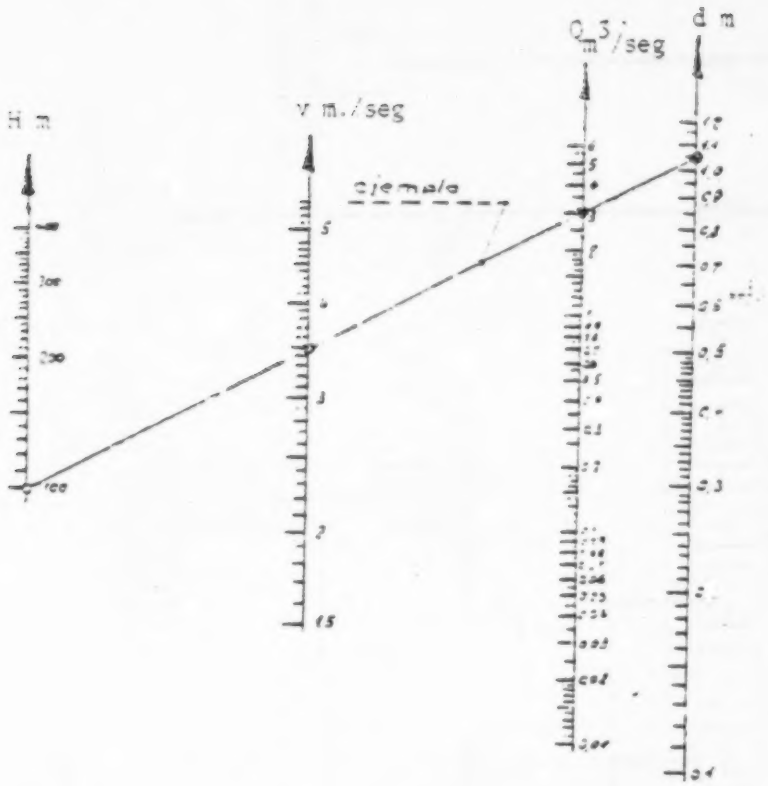
DIAGRAMA UNIFILIAR TABLERO ASINCRONICO

No. 2



(9)

GRAFICO PARA DETERMINAR EL DIAMETRO ECONOMICO DE UNA TUBERIA DE PRESION



H = salto en metros
Q = caudal en m^3/seg.
d = diámetro de tubería
v = velocidad del agua